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NOTES ON GEOGRAPHIC DISTRIBUTION

Rediscovery and range extension of *Crocidura* spp. (Eulipotyphla, Soricidae) in West Java, Indonesia

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Abstract. *Crocidura* Wagler, 1832 is a widespread genus with high micro-endemism. Unfortunately, its Javan species lacks adequate information on its geographic distribution. Here, we present the first record of *Crocidura umbra* Demos, Achmadi, Handika, Maharadatunkamsi, Rowe & Esselstyn, 2016 from Mount Papandayan, which was previously thought to be endemic to Mount Gede, expand the geographic range of *Crocidura orientalis* Jentink, 1890 on Mount Papandayan and *Crocidura monticola* Peters, 1870 on Mount Sawal, and rediscover *Crocidura brunnea* Jentink, 1888 in Javan lowland forest. The new data provide important information to better understand this inadequately studied genus of small mammal on Java.

Key words. Forest-dependent taxon, insectivore, Leuweung Sancang, micorendemism, Mount Papandayan, Mount Sawal, white-toothed shrew

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INTRODUCTION

The genus *Crocidura* Wagler, 1832, commonly known as white-toothed shrews, is a remarkably diverse and widespread group distributed across the Afrotropical, Palaearctic, Sundaland biogeographic regions, and it even reaches Sulawesi and the Philippines (Jenkins 1982). Apart from its rich diversity, this genus exhibits notable micro-endemism in some species (Demos et al. 2016). The limited geographic distribution of some *Crocidura* species, coupled with their cryptic nature, has resulted in continuing species discoveries within this genus, particularly in Indonesia. Recent research efforts have unveiled 14 previously unknown species in Sulawesi, two in Java, and three most recently described species from Sumatra (Demos et al. 2017; Esselstyn et al. 2014, 2021; Nations et al. 2024).

Drawing insights from these recent updates, Java displays lower diversity, which can be attributed to its high possibility for harboring cryptic diversity (Esselstyn et al. 2013; Demos et al. 2017; Hutama et al. 2017; Hubert et al. 2019; Sholihah et al. 2020, 2021a, 2021b; Dahruddin et al. 2021; Hinckley et al. 2022; Utami et al. 2022). Since the 2000s, expeditions have been recorded on Mount Gede-Pangrango, Mount Ciremai, and Mount Salak, areas that were previously surveyed in the 1900s (Ruedi 1995; Esselstyn et al. 2013). To date, six species have been identified on the island, with five inhabiting West Java. Notably, two species, *Crocidura umbra* Demos, Achmadi, Handika, Maharadatunkamsi, Rowe & Esselstyn, 2016 and *C. abscondita* Esselstyn, Achmadi, & Maharadatunkamsi, 2014, were ascribed exclusively to Mount Gede (Esselstyn et al. 2014; Demos et al. 2017).

These newly described species provided more comprehensive representation of the island's shrew population (Esselstyn et al. 2013; Demos et al. 2017). Nevertheless, it may still contain bias as survey efforts have been concentrated in specific locations with new areas yet to be explored. Moreover, given current advancements in taxonomic descriptions and pronounced micro-endemism (Demos et al. 2016), the possibility of discovering unique records in unexplored areas remains high. Consequently, our studies were launched in three previously uninvestigated sites in West Java: Mount Papandayan, Mount Sawal,

and Leuweung Sancang. These three places represent different mountain systems and elevations. Mount Papandayan peaks at 2,655 m above sea level (a.s.l.), Mount Sawal peaks at 1,764 m a.s.l., and Leuweung Sancang is a lowland and coastal forest, located in southern part of West Java, directly adjacent to the Indian Ocean with maximum elevation of 175 m a.s.l. (Figure 1). Investigation in Leuweung Sancang holds important value as it is in the lowland forest (0–1,000 m a.s.l.), which covers the largest part of tropical forest in Indonesia (Nugraha and Kusmana 2022) and is mostly unsurveyed in term of *Crocidura* exploration in Java (Jenkins 1982; Ruedi 1995).

METHODS

The survey was conducted from April 28 to May 22, 2023 on Mount Papandayan, Mount Sawal, and Leuweung Sancang (Figure 1, mapped using QGIS v. 3.36.2), with sampling carried out (administratively) under Surat Izin Masuk Kawasan Konservasi (SIMAKSI, the entry permit) number SI.999/K.1/BIDTEK.1/KSA/3/2023 and Surat Ijin Pengambilan Sampel (Sampling Permit) number SK.70/K.1/BIDTEK.1/KSA/3/2023; while the collected specimens were transported based on Surat Angkut Tumbuhan dan Satwa Dalam Negeri (SATS-DN, the Domestic Wild Plant and Animal Transport Letter) number SI.82/BKW.III/05/2023. All sites belong to secondary and/or primary forest, with additional riparian areas for Gunung Sawal and Leuweung Sancang. The three sites have different elevations: Mount Papandayan (ca. 2,200 m a.s.l.), Mount Sawal (ca. 1,000 m a.s.l.), and Leuweung Sancang (ca. 10 m a.s.l.). For each location, four days (three nights) of data collection were conducted with a combination of 55 traps that consist of 10 L bucket pitfall traps with drift fence, Victor traps, and Sherman traps. We used a mixture of peanut butter and “terasi”, a traditional shrimp paste, as bait.

Sample processing was based on standard ethical procedures of the American Society of Mammalogists (Sikes 2016). The specimens obtained were euthanized using chloroform, documented, and the skull separated. Later, we preserved the specimens, which included preservation of skulls, tissue samples, and the bodies as voucher specimens. For preserving skulls, muscles were cleaned manually with a scalpel and the brain was cleaned by irrigation using a syringe. The cleaned skulls then preserved in 70% ethanol. We also secured materials to enable future molecular investigation by extracting tissue samples from the liver, which were then preserved in absolute ethanol. Lastly, we fixed the bodies of the specimen in 10% formalin and preserved them in 70% ethanol. All voucher specimens as well as tissue samples were then deposited at the Museum Zoologi ITB (catalog numbers MZI MAMM.0001 to MAMM.0011).

Taxonomic identity of the specimens was determined based on morphometric measurements (made using a stereomicroscope) of the following external characters: head and body length (HB), tail length (TL), and hind foot length without claw (HFL). Body weight (W) was also measured. The skulls were measured using the following characters: condylo-incisive length (CIL), breadth of braincase (BBC), interorbital width (IOW), rostral length (RL), rostral width (RW), postpalatal depth (PPD), postpalatal length (PPL), distance from occipital condyle to glenoid fossa (CGF), (9) upper toothrow length (UTL), and (10) distance from alveolar of the fourth premolar to the third molar (P^4-M^3) (Ruedi 1995; Esselstyn et al. 2013; Omar et al. 2013). The

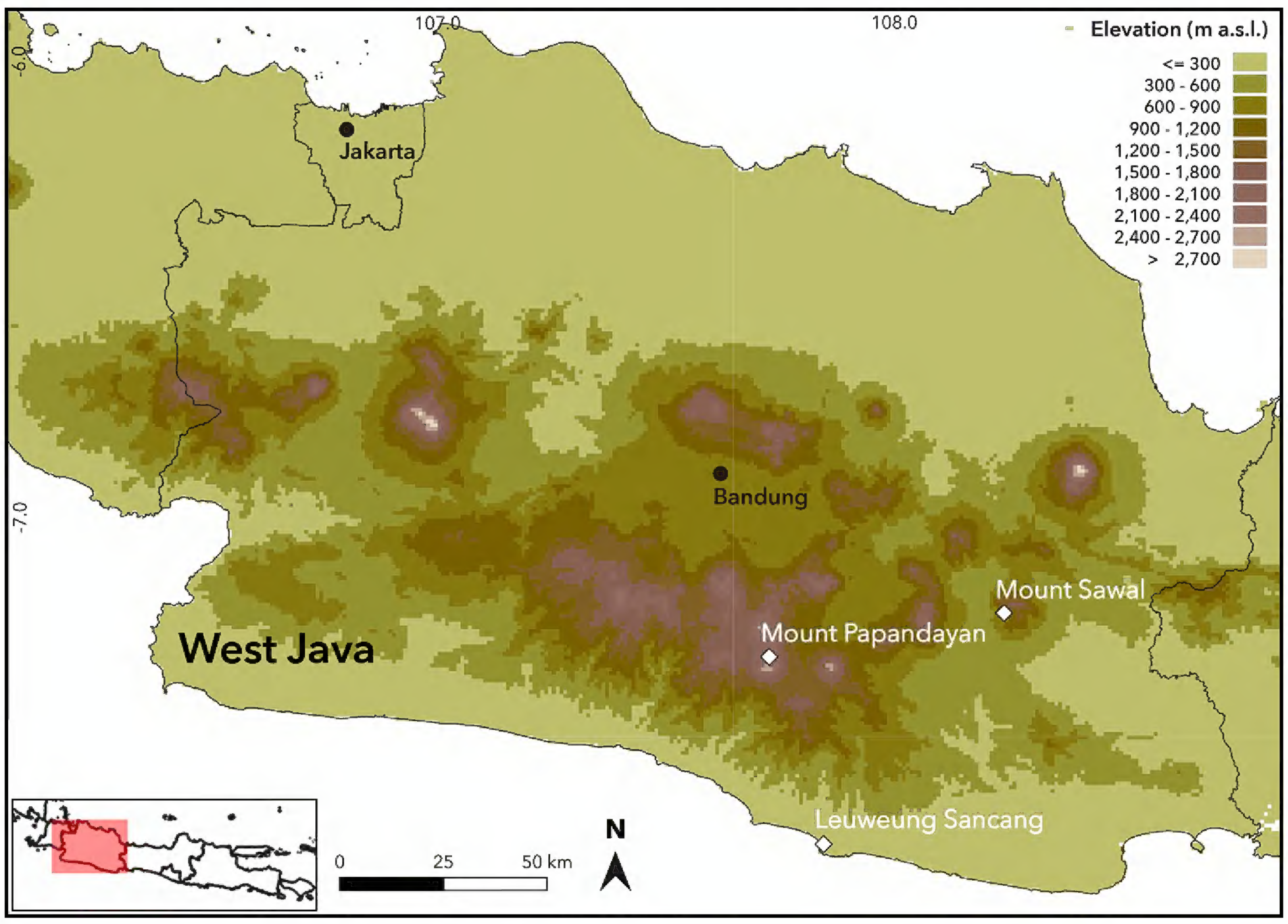

Figure 1. Map of research locations. Map is generated using QGIS v. 3.36.2 and edited using Adobe Illustrator 28.6.

occurrence data from this study have been uploaded to the Global Biodiversity Information Facility (GBIF). The dataset can be accessed at https://doi.org/10.15468/jtz52e.

RESULTS

Crocidura umbra **Demos, Achmadi, Handika, Maharadatunkamsi, Rowe & Esselstyn, 2016**
Figures 2, 3

New records. INDONESIA – WEST JAVA • Mount Papandayan, Supa Beureum; 07.3028°S, 107.7258°E; elev. 2,266 m a.s.l.; 30 Apr. 2023, 2 May 2023; M.Y. Samawi, I. Suryana, H. Fahrezi leg.; drift fences pitfall; MZI MAMM.0001, MAMM.0002, MZI MAMM.0006–MAMM0008.

Two specimens were obtained on April 30, 2023 (MZI MAMM.0001 and MAMM.0002), while the other three were obtained on May 2, 2023, at the same site (MZI MAMM.0006–MAMM0008).

Identification. Based on external measurements, these specimens are classified as a small Javan *Crocidura* (Omar et al. 2013) with HB of 62.2 ± 3.09 mm (Table 1) and a medium-length tail (Ruedi 1995; Demos et al. 2017), with ratio of tail to HB 78% ± 0.08%. This external size is larger than *C. monticola* and shorter tail compared with *C. abscondita*. Hindfoot length (HFL) without claw of *C. umbra* is also longer than that of syntopic species *C. monticola* (*C. umbra*: 10.2±0.17 mm, *C. monticola* from Mount Papandayan: 9.81 mm). However, Mount Papandayan specimens in our study tend to be smaller than previous descriptions of *C. umbra* at Mount Gede. In cranial size, the most apparent differences are CIL and BBC (CIL: 17.26 ± 0.1 mm, BBC: 7.93 ± 0.13 mm), which are smaller than *C. umbra* of Mount Gede (CIL: 17.81 ± 0.2 mm, BBC: 8.27 ± 0.19 mm; Table 1), but still larger than *C. monticola* of Mount Papandayan (CIL: 16.62 mm, BBC: 7.84 mm). The overall pelage of the specimen is darker than *C. maxi*, with brown tips on the dorsal pelage rather than almost white at the tips in *C. maxi* (Demos et al. 2017). Hence, the specimens were identified as *C. umbra*.

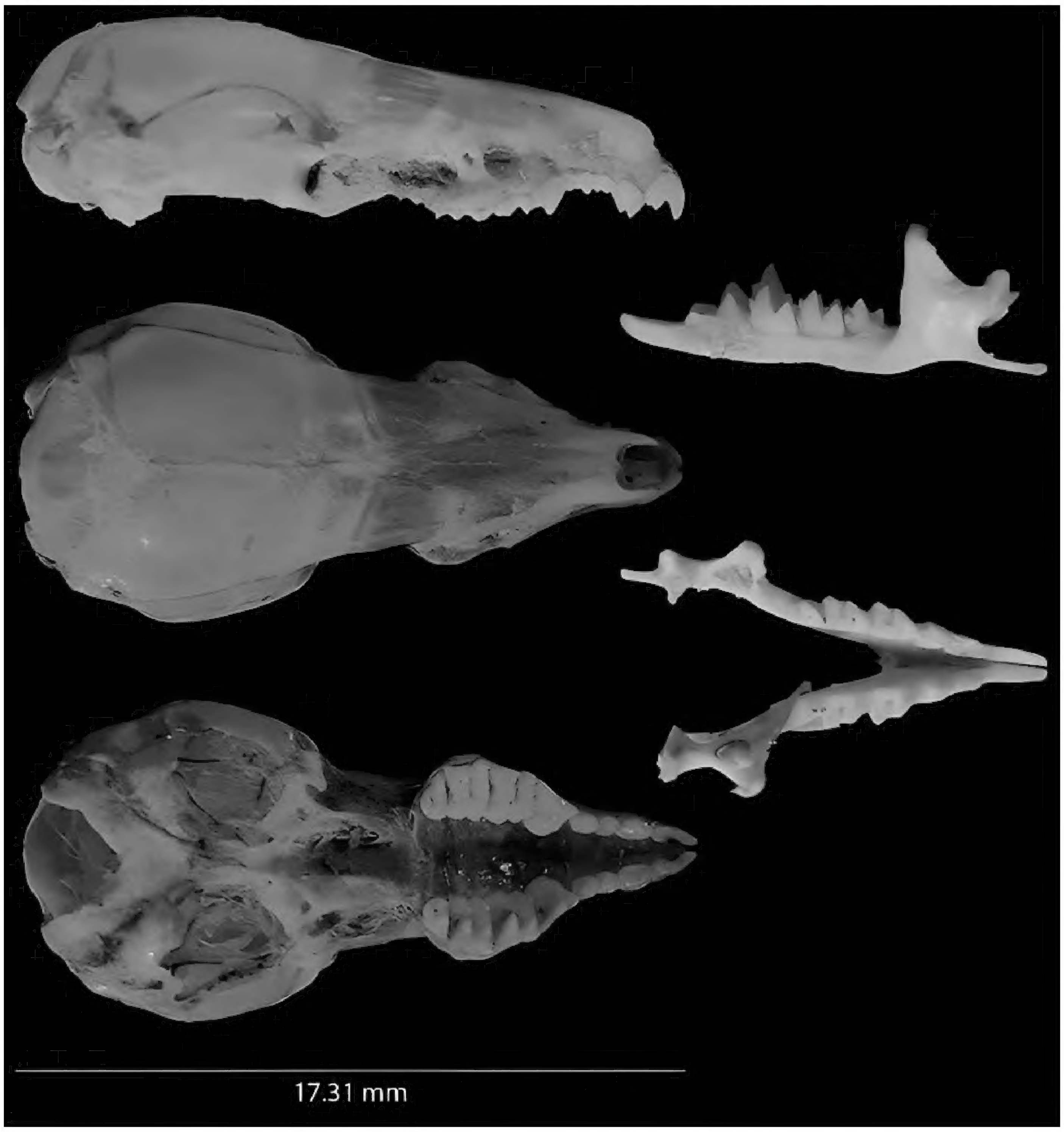

Figure 2. Skull pictures of *Crocidura umbra*. **A.** Maxilla, side, dorsal, and ventral view. **B.** Mandible, side and dorsal view. (Photographs by Maha Yudha Samawi)

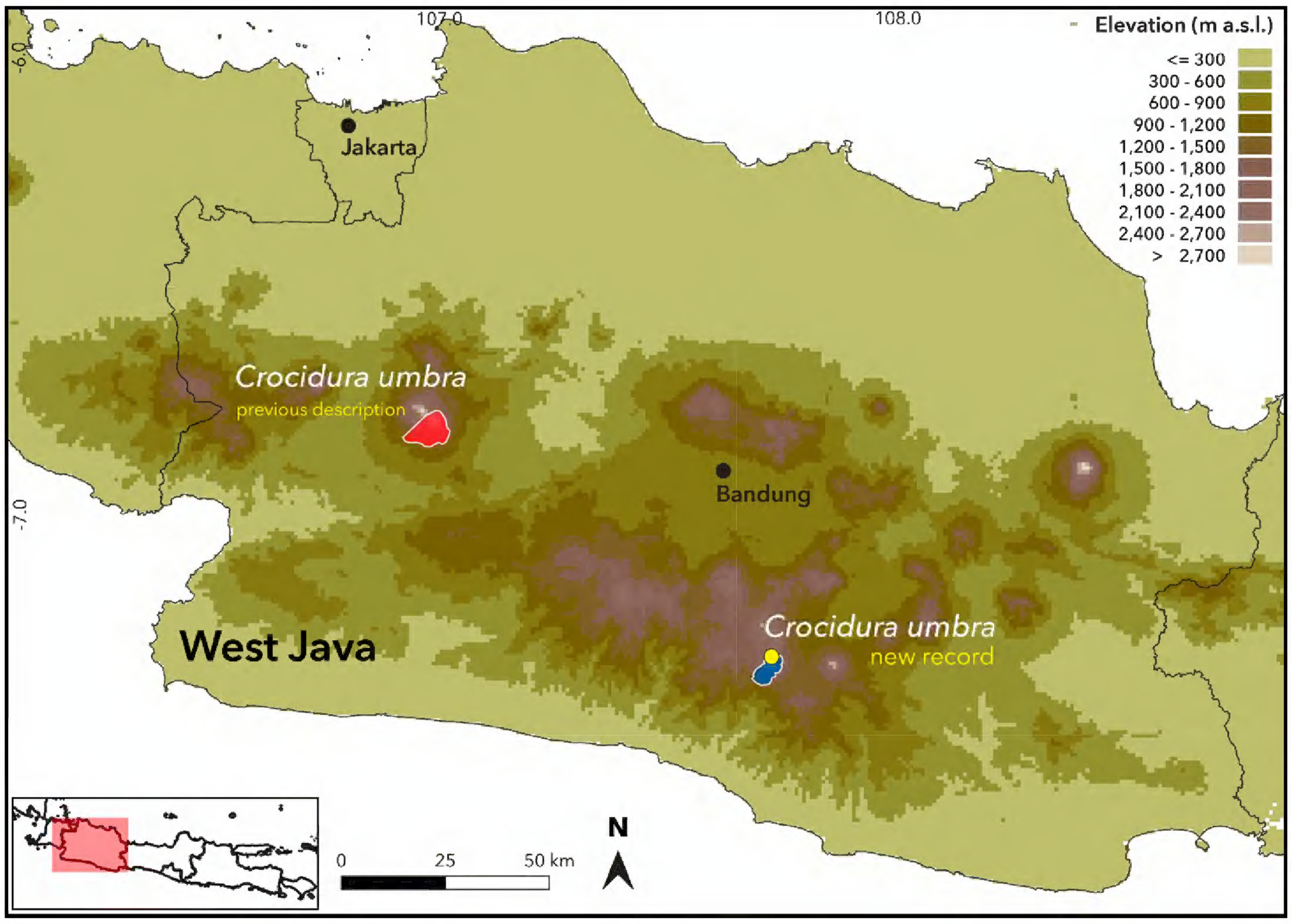

Figure 3. Distributional records of *Crocidura umbra*. Area highlighted in red represents previous historical records of the species, while blue area represents new findings from this study. Map is generated using QGIS 3.36.2 and edited using Adobe Illustrator 28.6.

Crocidura orientalis **(Jentink, 1890)**
Figures 4, 5

New records. INDONESIA – West Java • Mount Papandayan, Supa Beureum; 07.3108°S, 107.7240°E; elev. 2,266 m a.s.l.; 1 May 2023; M.Y. Samawi, I. Suryana, H. Fahrezi leg.; found dead on the forest path; MZI MAMM.0005.

This specimen was found dead (uninjured) on the forest path nearby the trap site. Since the observation, local people said that they often found dead shrews on the forest path without a definite cause.

Identification. This specimen is large (HB: 81.9 mm; Table 1) with three unicuspids (Figure 3) characterizing the genus *Crocidura*, which is different from *Suncus* (with four unicuspids) (Omar et al. 2013). This species' hair is distinctive as it is longer and softer than in *C. brunnea*. In addition, the tail of this species is long (67.1 mm; Table 1) and covered only with very short coats and lacks bristles (Ruedi 1995).

Crocidura monticola **(Peters, 1870)**
Figures 6, 7

New records. INDONESIA – West Java • Mount Sawal, Pasirtamiang; 07.2067°S, 108.2399°E; elev. 1,025 m a.s.l.; 17 May 2023; M.Y. Samawi, J. Natanael, I. Jaya leg.; drift fences pitfall; MZI MAMM.0010 • Mount Papandayan, Supa Beureum; 07.3028°S, 107.7258°E; elev. 2,266 m a.s.l.; 1 May 2023, 2 May 2023; M.Y. Samawi, I. Suryana, H. Fahrezi leg.; drift fences pitfall; MZI MAMM.0003–MAMM.0004.

Identification. Among the species found in this study, *Crocidura monticola* is the smallest (HB Mount Sawal: 67 mm, HB Mount Papandayan: 63 mm; Table 1). Compared to the other specimens that we observed, *C. monticola* is most generally similar to *C. umbra* from Mount Papandayan but with a smaller CIL (CIL Mount Sawal: 16.41 mm, CIL Mount Papandayan: 16.62 mm; Table 1). The constantly smaller size of the CIL, supported by the characters of narrower rostral width and zygomatic plate, more angular premaxilla (not in a horizontal plane as in *C. umbra*), and lighter lip pigmentation suggest that this specimen is *C. monticola* (Demos et al. 2017).

In the description by Demos et al. (2017), it has been explained that when they are found together and that *C. monticola* and *C. umbra* do not overlap in size, with *C. monticola* consistently smaller. This phenomenon was also observed by us. By comparing *C. monticola* from only Mount Papandayan and *C. umbra* from the same area (syntopic), *C. monticola* specimens are indeed generally smaller. On the contrary, this pattern disappeared as we found overlapping size when we compared the size of all observed *C. monticola* specimens (from both Mount Papandayan and Mount Sawal) with *C. umbra* (from Mount Papandayan).

Crocidura brunnea **(Jentink, 1888)**
Figures 8, 9

New records. INDONESIA – West Java • Leuweung Sancang, Cijeruk; 07.7122°S, 107.8451°E; elev. 10 m a.s.l.; 13 May 2023; M.Y. Samawi, A. Nofianto, J. Natanael leg.; Sherman Trap; MZI MAMM.0009 • Mount

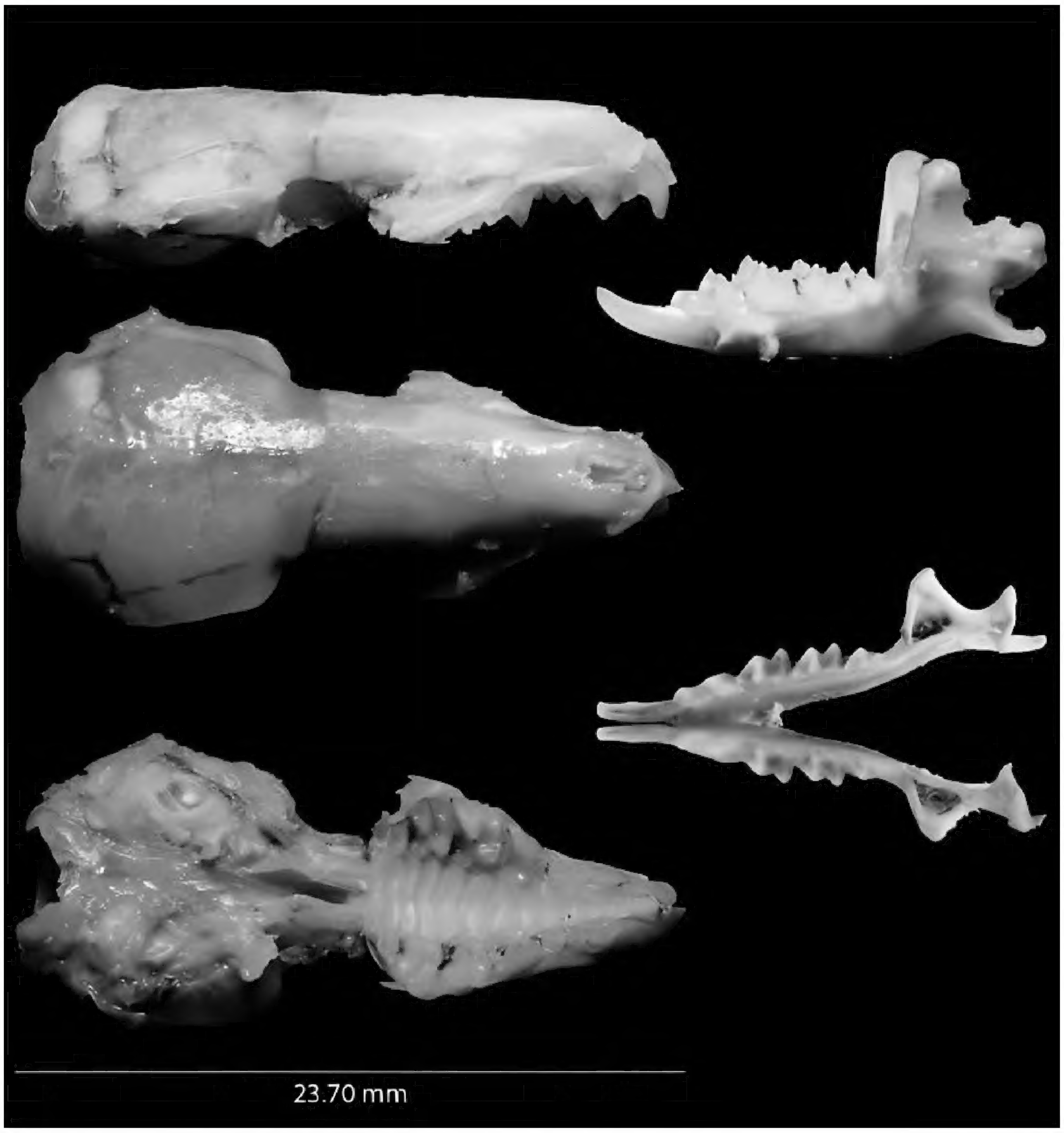

Figure 4. Skull pictures of *Crocidura orientalis*. **A.** Maxilla, side, dorsal, and ventral view. **B.** Mandible, side and dorsal view. (Photographs by Maha Yudha Samawi & Ganjar Cahyadi)

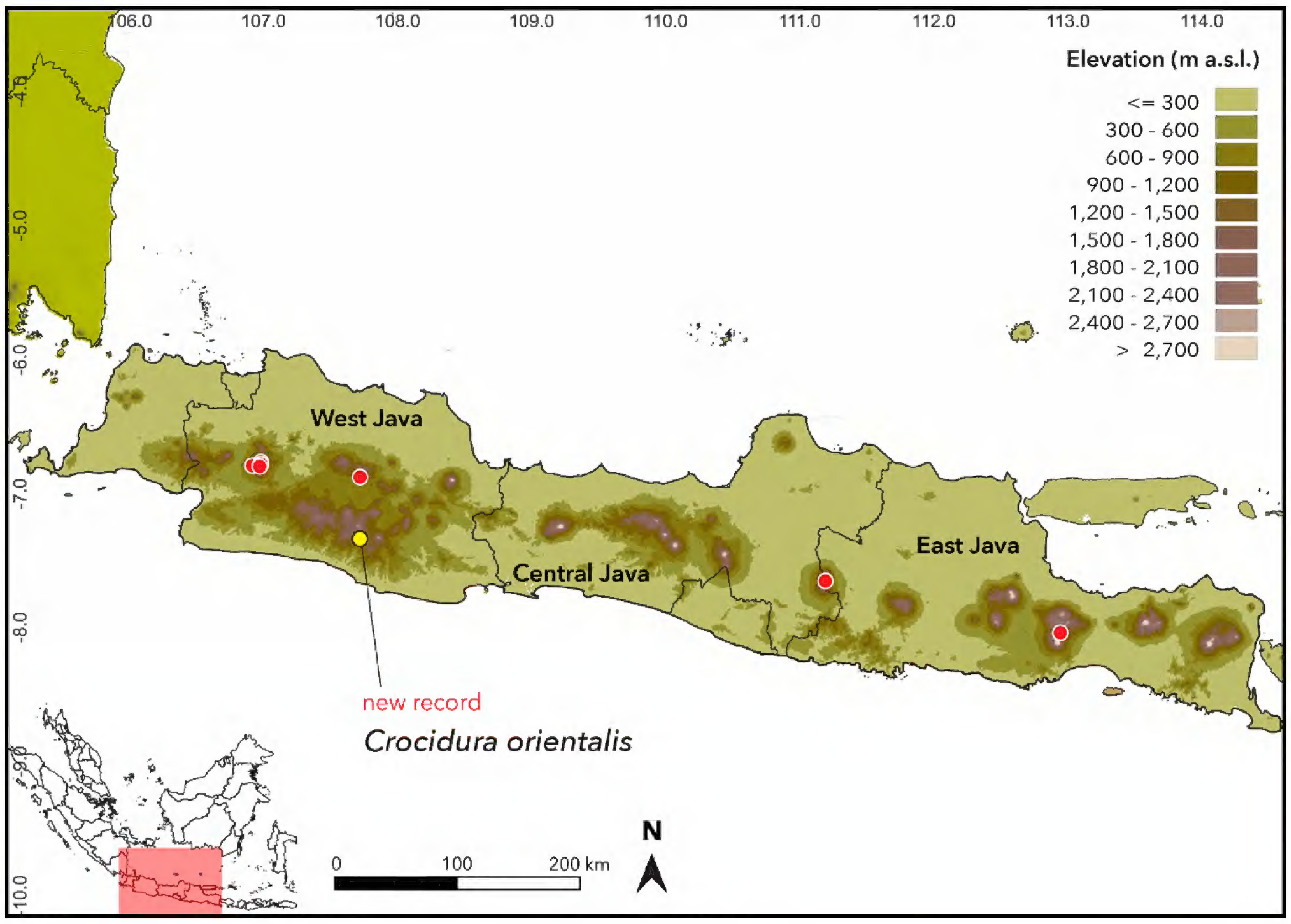

Figure 5. Distributional records of *Crocidura orientalis*. Red dots represent previous historical records of the species in several areas in Java, while yellow dot respresents new record of *C. orientalis* in Mount Papandayan, West Java. Map is generated using QGIS 3.36.2 and edited using Adobe Illustrator 28.6.

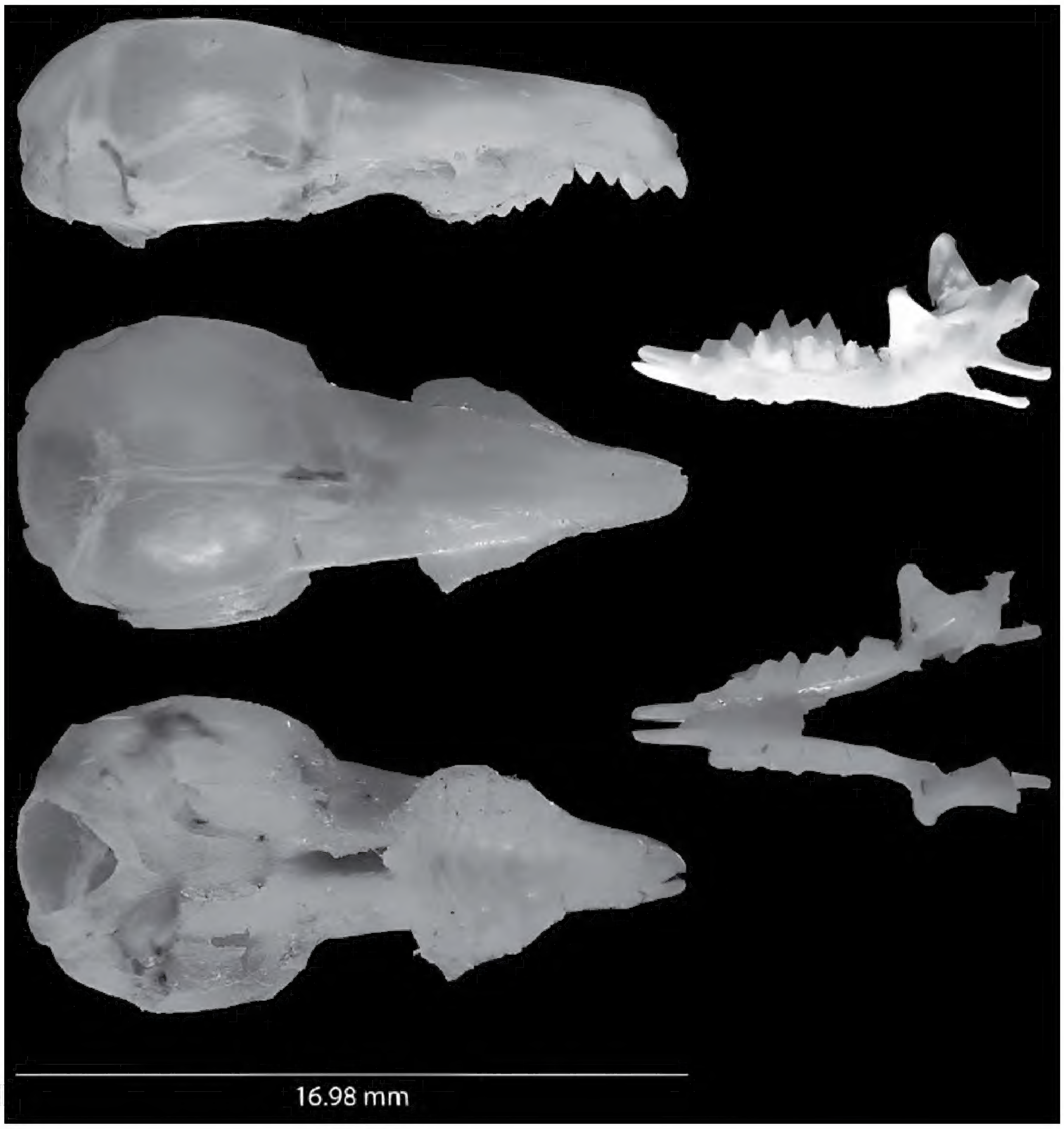

Figure 6. Skull pictures of *Crocidura monticola*. **A.** Maxilla, side, dorsal, and ventral view. **B.** Mandible, side and dorsal view. (Photographs by Maha Yudha Samawi)

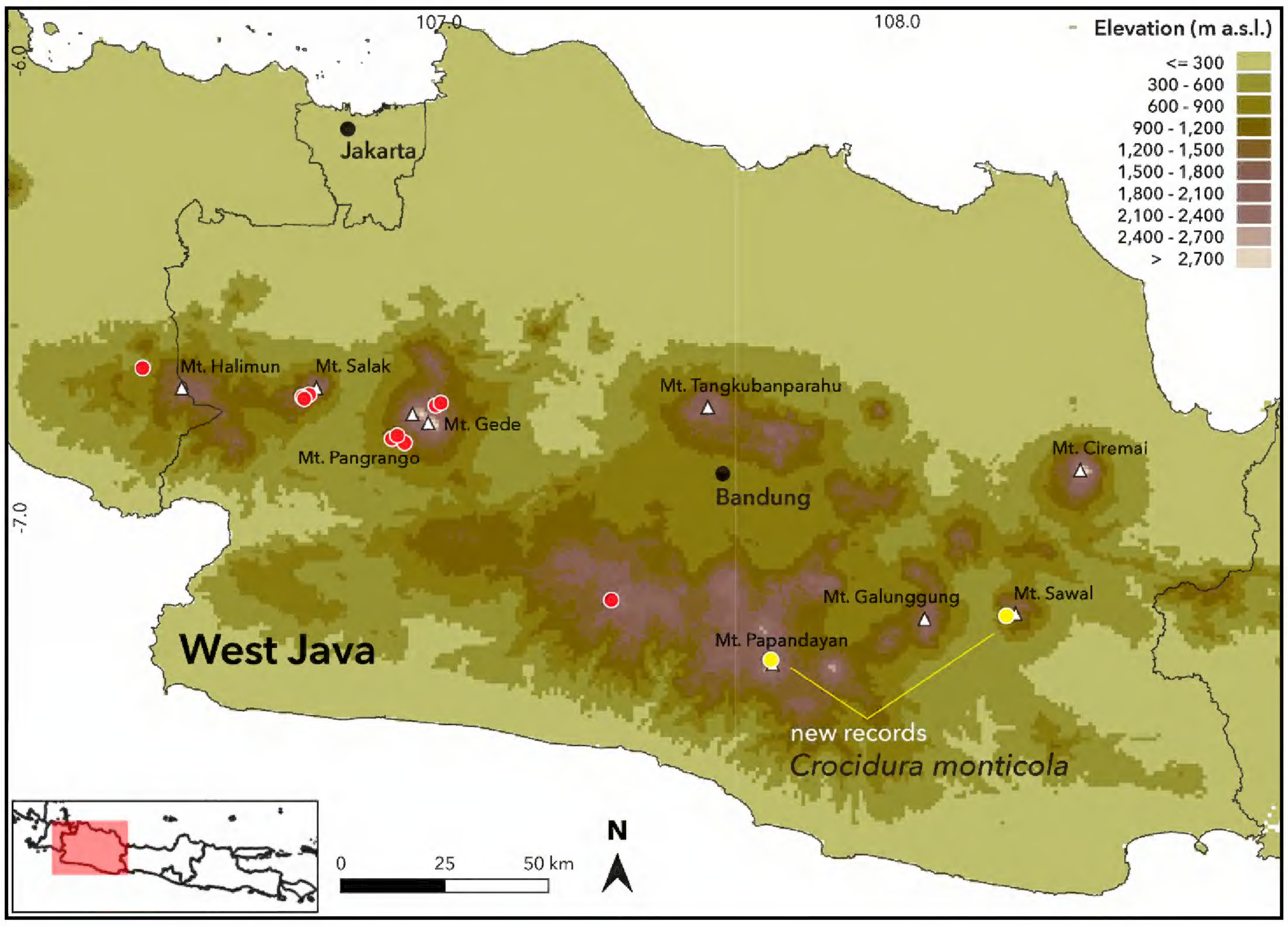

Figure 7. Distributional records of *Crocidura monticola*. Red dots represent previous historical records of the species which were mostly located in Gede-Pangrango-Halimun-Salak mountain range. Yellow dots respresent new distributional records of *C. monticola* in Mount Papandayan, and Mount Sawal, shifting the eastern distribution border further to the east edge of West Java. Map is generated using QGIS 3.36.2 and edited using Adobe Illustrator 28.6.

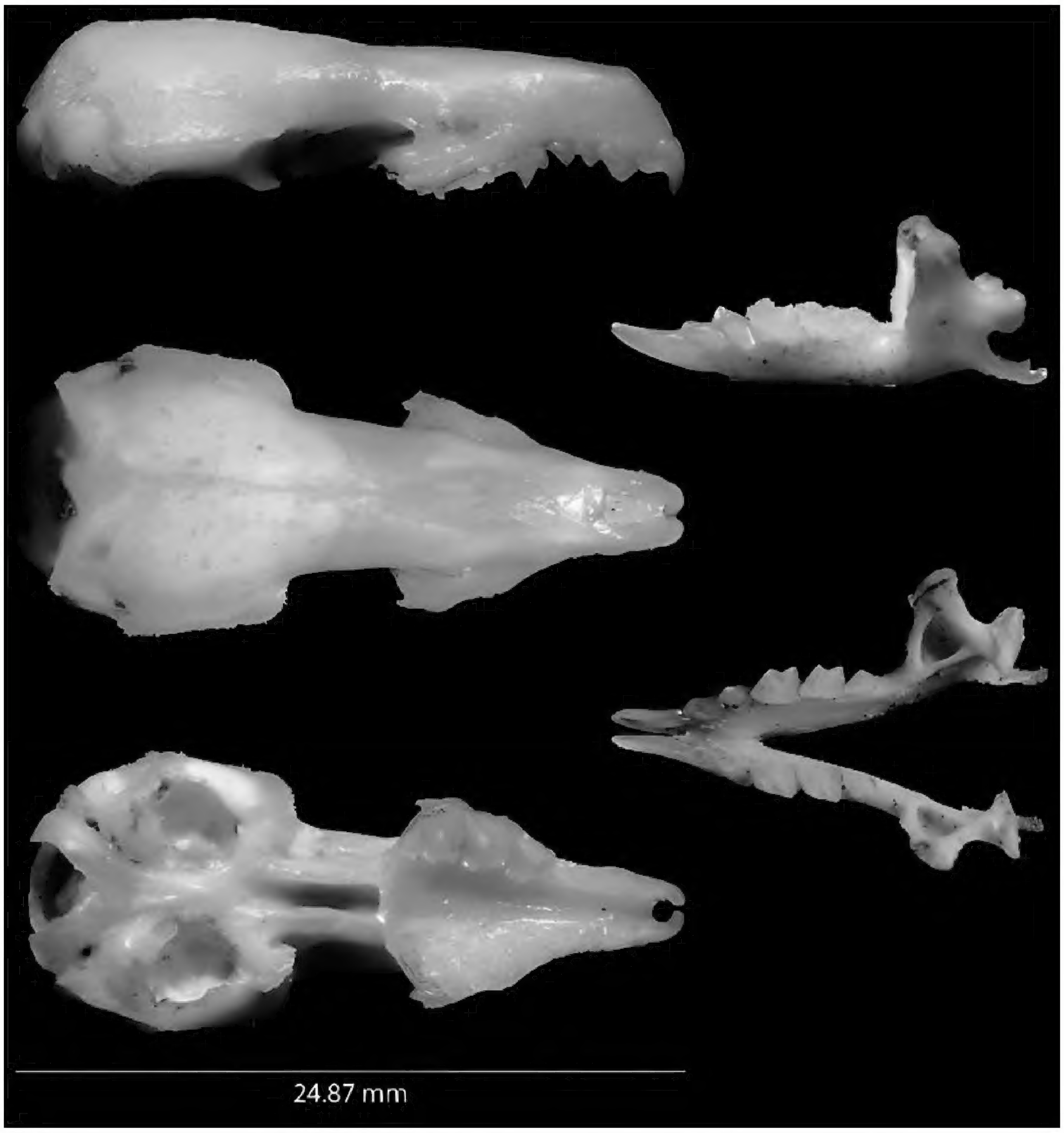

Figure 8. Skull pictures of *Crocidura brunnea*. **A.** Maxilla, side, dorsal, and ventral view. **B.** Mandible, side and dorsal view. (Photographs by Amadeus Devin Gouw & Maha Yudha Samawi)

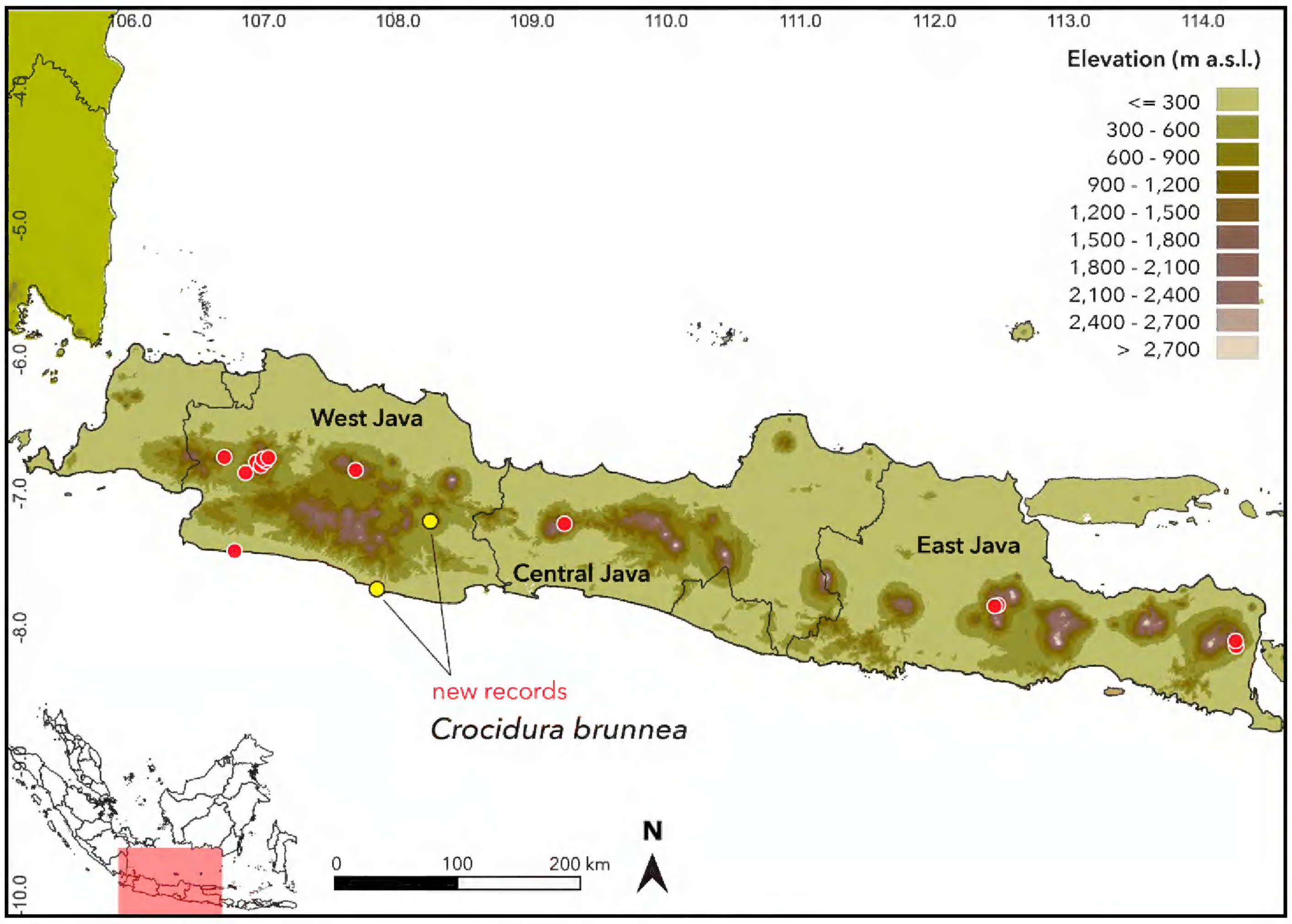

Figure 9. Distributional records of *Crocidura brunnea*. Red dots represent previous historical records of the species, while yellow dots respresent new distributional records of *C. brunnea* from current study in Mount Sawal (north, elevation 1,025 m a.s.l.) and Leuweung Sancang (south, elevation 10 m a.s.l.). Map is generated using QGIS 3.36.2 and edited using Adobe Illustrator 28.6.

Table 1. Result of Morphometric Measurements: condylo-incisive length (CIL), breadth of braincase (BBC), interorbital width (IOW), rostral length (RL), rostral width (RW), postpalatal depth (PPD), postpalatal length (PPL), distance from occipital condyle to glenoid fossa (CGF), upper toothrow length (UTL), distance from alveolar of the fourth premolar to the third molar (P^4-M^3), head and body length (HB), tail length (TL), hind foot length without claw (HFL), and body weight (W). All measurements are in millimeters (mm), except for body weights (W) are in grams (g).

Variable	*C. umbra* Mt. Papandayan (n = 5) (this study)	*C. umbra* Mt. Gede (*n* = 15) (Demos et al. 2016)	*C. orientalis* Mt. Papandayan (*n* = 1) (this study)	*C. orientalis* (*n* = 5) (Demos et al. 2016)	*C. monticola* Mt. Sawal (*n* = 1) (this study)	*C. monticola* Mt. Papandayan (*n* = 2) (this study)	*C. monticola* (*n* = 31) (Demos et al. 2016)	*C. brunnea* Leuweung Sancang (*n* = 1) (this study)	*C. brunnea* Mt. Sawal (*n* = 1) (this study)	*C. brunnea* (*n* = 51) (Ruedi 1995)
CIL	17.26 ± 0.10 (17.08–17.33)	17.81 ± 0.28 (17.17–18.29)	23.70	23.4 ± 0.5 (22.4–24.6)	16.41	16.62 (16.25–16.98)	16.47 ± 0.50 (15.53–17.55)	23.32	24.87	24.3 ± 0.6 (23.1–25.8)
BBC	7.93 ± 0.13 (7.8–8.11)	8.27 ± 0.19 (8.06–8.67)	9.55	10.1 ± 0.2 (9.6–10.6)	6.89	7.84 (7.67–8.01)	7.44 ± 0.21 (7.08–8.04)	10.4	10.5	10.3 ± 0.3 (9.7–10.9)
IOW	4.18 ± 0.19 (3.96–4.48)	4.05–0.09 (3.88–4.21)	4.86	5.1 ± 0.2 (4.6–5.4)	3.68	3.97 (3.95–3.99)	3.56 ± 0.14 (3.30–3.90)	4.88	5.16	4.8 ± 0.2 (4.5–5.7)
RL	6.99 ± 0.18 (6.72–7.16)	6.97 ± 0.13 (6.81–7.24)	10.7	9.8 ± 0.3 (9.3–10.5)	6.47	6.88 (6.69–7.06)	6.40 ± 0.28 (5.75–7.01)	9.53	10.7	9.9 ± 0.3 (9.3–10.6)
RW	2.26 ± 0.06 (2.18–2.32)	2.49 ± 0.12 (1.92–2.19)	3.21	2.9 ± 0.2 (2.4–3.5)	1.99	2.31 (2.25–2.36)	2.03 ± 0.08 (1.92–2.19)	3.59	3.77	3.2 ± 0.2 (2.7–3.6)
PPD	3.41 ± 0.06 (3.35–3.5)	3.35–0.12 (3.14–3.59)	4.6	4.1 ± 0.1 (3.9–4.5)	3.18	3.38 (3.29–3.46)	3.02 ± 0.13 (2.71–3.30)	4.62	4.53	4.2 ± 0.2 (3.9–4.5)
PPL	8.13 ± 0.20 (7.84–8.30)	8.17 ± 0.16 (7.95–8.61)	10.8	10.4 ± 0.3 (9.7–11)	7.83	7.78 (7.75–7.81)	7.48 ± 0.19 (7.12–7.87)	11	11.1	10.6 ± 0.3 (9.8–11.2)
CGF	7.21 ± 0.04 (7.16–7.27)	7.46 ± 0.18 (7.10–7.72)	8.55	8.9 ± 0.2 (8.5–9.2)	7.12	7.16 (7.05–7.26)	6.78 ± 0.15 (6.58–7.16)	9.11	9.46	9.1 ± 0.3 (8.4–9.6)
UTL	7.58 ± 0.11 (7.43–7.74)	7.63 ± 0.12 (7.45–7.82)	10.9	10.3 ± 0.3 (9.7–10.9)	7.11	7.29 (7.12–7.45)	7.07 ± 0.26 (6.56–7.63)	10.8	11.2	10.9 ± 0.3 (10.3–11.7)
P^4-M^3	4.38 ± 0.06 (4.28–4.45)	4.41 ± 0.14 (4.22–4.71)	6.1	5.7 ± 0.2 (5.4–6)	4.11	4.25 (4.15–4.35)	4.01 ± 0.15 (3.71–4.41)	6.16	6.16	6.0 ± 0.2 (5.5–6.8)
HB	62.2 ± 3.09 (58.4–66)	67.9 ± 2.02 (63–71)	81.9	87.9 ± 5.8 (73–100)	67	63 (62.6–63.4)	60.8 ± 4.49 (53–70)	79.7	96.5	91.7 ± 6.7 (73–104)
TL	48.1 ± 3.76 (42.7–51)	52.6 ± 3.72 47–58	67.1	77.2 ± 6.6 (62–86)	42.5	50.7 (49.9–51.5)	42.9 ± 5.80 35–59	42.9	55	55.7 ± 5.6 (42–64)
HFL	10.2 ± 0.17 (10.1–10.5)	—	14.19	—	9.81	9.81 (9.74–9.88)	—	14.06	14.33	15.6 ± 0.7 (13.5–17)
W	6.63 ± 0.73 (5.51–7.53)	6.11 ± 0.65 5.0–7.2	14.93	9.5–12.8	5.6	6.44 (6.28–6.6)	4.2 ± 0.68 (3.4–6.3)	15.5	16.9	12.8–17

Sawal, Pasirtamiang; 07.2067°S, 108.2399°E; elev. 1,025 m a.s.l.; 18 May 2023; M.Y. Samawi, J. Natanael, I. Jaya leg.; drift fences pitfall; MZI MAMM.0011.

Identification. This species is enormous compared to other Javan *Crocidura*, but it still has three unicuspids and, thus, belongs to genus *Crocidura* and is not member of the genus *Suncus* Ehrenberg, 1832. Compared to *C. orientalis*, this species has a shorter tail, shorter hairs, and bristles on the tail (Ruedi 1995). Our specimens have mean TL of 55 mm (Table 1) with no notable differences between specimens found in lowland Leuweung Sancang and in higher submontane forest of Mount Sawal.

DISCUSSION

The discovery of new distribution records of the genus *Crocidura* in previously unsurveyed locations in Java holds significant implications for our understanding of the ecology and biodiversity of Javan *Crocidura*. In time between the late 1900s and early 2000s, surveying previous sites was important to ensure that new specimens could be linked with earlier-described species. However, such surveys failed to add more information on the distributions of this genus, as they left many areas of Java unexplored. Although Demos et al. (2016) described many species as micro-endemic, the possibility of discovery of some species in broader areas than previously known exists, especially for the small-*Crocidura* group (Omar et al. 2013).

The description of this group is dynamic, as it is difficult to collect specimens of species that are very cryptic (Ruedi 1995). Earlier studies described *Crocidura monticola* using a holotype from Mount Lawu, attributed to Central and East Java, which is due to Mount Lawu being located at the border between the

two provinces (Peters 1870). Later studies recognized *C. maxi* as a distinct species from East Java (Jenkins 1982; Kitchener et al. 1994). Further research and explorations contributed to taxonomic changes. While Ruedi (1995) grouped all Javan shrews into *C. monticola*, Omar et al. (2013), by referring to Kitchener et al. (1994) and Jenkins (1982), redivided Javan shrews into two groups based on morphological and phylogenetic analyses, namely *C. monticola* for species in western Java and *C. maxi* for species in eastern Java. With this well-defined classification, Ruedi's presumption of the existence of long-tailed specimens treated as *C.* cf. *paradoxura* from West Java (Ruedi 1995) was again explored and described by Demos et al. (2017) as *C. umbra*.

Crocidura umbra is a unique species because it is very similar morphologically to *C. maxi* from eastern Java but phylogenetically closer to *C. monticola* from western Java, probably due to higher probability of interspecific gene flow (Demos et al. 2016). Unfortunately, that study found this species on only Mount Gede. West Java has a complex mountain system with many mountain ranges. Previous studies have focused on only the Gede Pahala mountain range (Mount Gede-Pangrango-Halimun-Salak) and the separate Mount Ciremai in north-eastern West Java. The absence of this species on Mount Salak from the same mountain range is a strong reason for previous studies to suggest that the distribution of *C. umbra* is restricted to one mountain.

The discovery of our new occurrence records (Figure 3), which are located approximately 100 km from the original findings, is a reminder of the need to further document species occurrences, particularly within separate mountain ranges. Notably, Mount Papandayan, a different mountain system in West Java, possesses specific forest characteristics that differentiate it from Mount Gede. Despite being an active volcano, with its most recent major eruption recorded in 2002 (Abidin et al. 2006; Hadisantono 2006) and having faced challenges like illegal logging and forest fires, the findings assume even greater significance due to the study's focus on an area that is still in the process of reaching its peak succession (secondary forest) after experiencing substantial disturbances. This underscores the presence of a well-connected source population in this region, which plays a vital role in sustaining biodiversity.

Similar trends emerge in the case of Mount Sawal, where the area once functioned as a plantation around the 1960s. This historical context holds importance because *Crocidura*'s habitat requirements are specific. Most *Crocidura* species in Java are recorded from forested environments (Omar et al. 2013; Hinckley et al. 2022). Consequently, it has been assumed that the connectivity among various forest patches becomes paramount for successfully progressing disturbance-prone areas. Our newfound distribution records emphasize the need for continuous exploration and investigation in other alternative habitats with various ecological niches. These findings underscore species' resilience within challenging environments and highlight the crucial role of connectivity among habitats for maintaining biodiversity. In addition, while several works have recovered border between West Java and Central Java as possible biogeographic break (Meyer et al. 2011; Hutama et al. 2017; Hamidy et al. 2018) separating western and eastern part of the island and the study of Omar et al. (2013) has split the small-*Crocidura* group in Java into *C. monticola* in western Java and *C. maxi* in the eastern Java, the distribution limit of these two species remains unclear. With previous studies focused on the western most mountains of Java, the mountains in central part of the island which are thought to be the hypothetical distribution limit of these species have not been surveyed (Ruedi 1995; Esselstyn et al. 2013). Therefore, our findings in the more centrally located Mount Sawal (Figure 7), which are also in relative proximity with the hypothetical biogeographic break in Java (Meyer et al. 2011; Hutama et al. 2017; Hamidy et al. 2018), could represent a clearer distribution limit for this species.

Crocidura brunnea is the only *Crocidura* native to Java documented in low elevation (Ruedi 1995) with specimens can be found from sea level to 1,700 m. Jenkins (1982) initially characterized *Crocidura* from coastal Pelabuhan Ratu (West Java) recorded initially by Bartels (1937) as *C. fuliginosa brevicauda* and the mountain individuals as *C. f. orientalis*. However, Ruedi (1995) revised this description, identifying two distinct large-*Crocidura* species, sequentially as *C. brunnea* and *C. orientalis*. The separation between these two species is based on morphological characteristics and elevation, in which *C. brunnea* is occupying lower elevations and *C. orientalis* can be found at higher elevations (Ruedi 1995). Intermediate elevations (ca. 1,500 m a.s.l.) serve as a zone of sympatry for both species—although in this study, *C. orientalis* was found on Mount Papandayan (Figure 5) and sympatry with the relatively new species *C. umbra*. To date, most *C. brunnea* records exist in the elevation range of 1,000–1,700 m a.s.l. with original information from Bartels (1937) as the sole record of a lowland *Crocidura* in Java. In this case, our study rediscovered this species in the lowlands (Figure 9), giving hope that there are still patches of Javanese lowland forest that are adequate for *Crocidura* habitat, despite the fragmentation issue.

Given the extensive fragmentation of habitats in Java (Ekawati et al. 2015), documenting biodiversity in the island becomes an urgent necessity. In the case of Javan *Crocidura*, exploring more unsurveyed areas such as the remaining lowland forests, traditional agroforests (with good resemblance to the secondary forest), post-plantation areas (lesson from the case of Mount Sawal), successive disturbed forest (lesson from the case of Mount Papandayan) and other alternative habitats can be crucial in capturing more information regarding habitat preferences and elevation ranges of this group since the majority of existing records primarily pertain to forests in highland areas.

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Conflict of interest
The authors declare that no competing interests exist.

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No ethical statement is reported.

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Authors' contributions
Conceptualization: MYS, AS, ADP. Data curation: MYS, AS, GC. Formal analysis: MYS, GC. Funding acquisition: AS, MYS, ADP. Investigation: MYS, JN, AN, ASa, IJ, IS, HF, ADG. Methodology: MYS, AS, ADP, GC. Resources: AS, MYS, ADP, ASa. Supervision: AS, ADP. Visualization: MYS, AS. Project administration: AS, MYS, ADP. Software: MYS, AS. Validation: GC, AS. Writing – original draft: MYS, AS, GC. Writing – review and editing: MYS, AS, GC, ADP, JN, AN, ASa, IJ, IS, HF, ADG.

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Data availability
All data that support the findings of this study are available in the main text.

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